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THE PRODUCTION OF DROP STAMPINGS.

Paper presented to the Institution, Coventry Section, December 4th, 1929, by P. O. Rowley.

THE origin of the drop forging industry is somewhat uncertain, but there is no doubt that its importance was first realised during the early days of the cycle trade. The need for quick production of finished machines created a necessity for raw products requiring the minimum amount of machining, and moreover, a need was felt for materials which would show uniformity in machining operations. Malleable cast iron was then, as now, a serious competitor, and at that time few attempts had been made to standardise its composition and treatment, with the result that hard castings were often encountered. Chain wheels, cranks, tube lugs, free wheels, etc., were produced as drop forgings. The production of a drop forged chain wheel was then considered an achievement.

The advent of the motor car introduced patterns which were much more complicated in shape and larger in size, and a demand for such parts necessitated improvements and extensions in drop forging plant. To-day, the most complicated brackets on the chassis, the largest flywheels, crankshafts, front and back axles are produced as drop forgings.

A drop forging may be considered as an article produced by the flow of hot plastic metal (steel, wrought iron, brass, duralumin), filling up the impressions in dies, the energy required being produced by the upper die (held in the hammer tup) falling under the action of gravity. This plastic flow of metal in the die, gives the drop forging its greatest advantage over hammer forgings or castings.

The distinction between drop forgings and castings must be carefully noted. One deals with the flow of plastic metal, while the other depends on the flow of molten metal. The failure by designers to realise this distinction often leads to a great amount of unnecessary trouble, owing to the complication of patterns to be drop forged.

Hammer forgings cannot be made to very fine limits, and they cannot, therefore, be machined in jigs, an essential requirement where mass production is concerned.

Castings of any kind have an inherent weakness, due to their manner of cooling. As everyone knows, hot solutions of such substances as copper sulphate, on cooling down, deposit crystals, the size of the crystal being larger the slower the cooling. Molten metals act in the same way as solutions, but the deposition of the metallic crystals is influenced by the mould. Cooling must naturally take place from the sides of the mould, and the metallic crystallisation will therefore take place in a direction at right angles to the mould faces. It is therefore easily seen that planes of weakness will exist where the crystals from adjacent faces meet, these weak places running from the corners towards the centre of the casting. As the casting cools, the shrinkage may cause the formation of cavities, thus rendering the casting weak. Apart from these defects, the gases, released as the metal cools down, may be trapped owing to the once molten metal becoming viscous, and thus, another source of weakness is introduced.

Steel for drop forgings which is originally in the cast ingot form, is always rolled down into billets or bars. This rolling has the effect of breaking down the crystalline structure with its planes of weakness, and actually rendering the steel fibrous in the direction of the rolling. In producing a drop forging, the steel is so arranged that the grain runs in the direction in which the greatest strength is required. This is easily shown by suitably etching a section of the forging, and bringing out what is known as the macrostructure.

Steels for Drop Forgings.

In the earliest days of the industry, the materials from which drop forgings were produced were limited to wrought iron and mild steel, the carbon content of which seldom rose above .25 per cent. The introduction of alloy steels, resulting in improvements in automobile design, called for more expert knowledge from the

drop forger, and it is now possible to have drop forgings made from practically every class of steel, excepting possibly very high carbon steels (over .7 per cent.) and high speed tool steels. We have in every-day use, plain carbon case-hardening steels, two to five per cent. nickel case-hardening steels, nickel chrome case hardening steels, carbon steels from .1 to .7 per cent. carbon, nickel steels from one to five per cent. nickel, chrome vanadium, nickel chrome oil and air hardening, chromium steels from one to 14 per cent. chromium, cobalt chrome steels. The designer has, therefore, a choice of steels giving a range of tensile strengths from eighteen to 120 tons per square inch.

The design of patterns which can be produced as drop forgings is only limited by the fact that there must be a taper towards the die line, and there must be no cavities running parallel with the die line. When considering the suitability of designs for drop forging, one must take into consideration the class of steel which is to be used. Patterns which can be readily produced from carbon steels may not be entirely satisfactory when produced from nickel chrome steels, owing to the less plastic nature of the latter.

Die Blocks.

In going into details of manufacture, the first question to be considered is the production of dies. These are made as forgings from high carbon (.6 per cent. C.) or nickel chrome steels, suitably normalised, heat treated, or in some cases surface hardened.

The dies are first planed on the surface, and the pattern is then lined out on both sides. Gauges and templates of the various sections are prepared, and the metal is then removed to form the impression by turning, shaping, milling or hand chipping, followed by filing and scraping. A fairly fine finish is essential, otherwise cracks are developed from the machining marks. All measurements on the dies have to allow for the shrinkage of metal on cooling, the allowance usually being about one-eighth inch per foot. On certain sections this shrinkage may possibly be more. The necessary taper must also be allowed, varying from three to ten degrees, so that as the forging shrinks, it can readily be removed from the die. When the dies are finished, lead proofs are usually made for the purpose of checking dimensions, and also for use in the preparation of clipping tools.

In some cases it is necessary to step the dies, as it is occasionally impossible to arrange the parting or die line on one plane. In some types of hammers which will be described later, multiple dies are used. These are so arranged that the whole of the roughing out and actual forging is done in one pair of dies. At the sides of the dies are sunk impressions for drawing and moulding, and in the central portion of the dies are the roughing and finishing impressions. The amount of work in the finishing impression is thus

reduced to a minimum, with the result that a larger number of forgings are produced without serious distortion of the finishing impression.

Forging Hammers.

We now turn our attention to the hammers. The most primitive of the hammers still in use are those called pulling hammers. These have a falling block or tup guided by vertical " V " slides, the tup being raised by means of a flat steel belt running over a rotating pulley.

On pulling the belt into close contact with the pulley, the tup is lifted, being allowed to fall on removing the tension on the belt. Various mechanical devices have been made in the form of friction hammers which eliminate the manual work required in the older form. The hammers operated in this manner are obviously restricted to fairly small weights, and when dealing with tups whose weight is measured in tons, some better method of lifting must be employed. The method most commonly used on English hammers is the steam lift. This consists of a cylindrical steam chest through the axis of which a shaft is mounted. The shaft is fitted with a vane which is actuated by steam introduced through the valve. A pulley wheel is fitted on the shaft, and this is connected by means of ropes to the hammer tup. The introduction of steam to the chest causes the shaft to rotate, lifting the hammer to its highest point. On shutting off the steam there is a slight expansion and the hammer then falls under the action of gravity. The valve is operated by means of a lever fitted at the side of the hammer, and the height to which the hammer is raised is regulated by the amount of steam which is allowed to enter the steam chest.

The foundations for this type of hammer are usually of concrete, and in the case of two/four-ton hammers, the bed is about sixteen feet thick. The anvil block is made of cast iron or cast steel, and in some cases of armour plates dovetailed together, and is fourteen to fifteen times heavier than the tup, so that a three-ton hammer has a block weighing about forty-five tons. The " V " shaped guide rods are dropped into pockets in the base of the hammer, and at the top are held by ash buffers and wedges. The tup has a free fall of about eight feet.

This type of hammer is usually worked in batteries of two or three. The smallest hammer is called the dummy, and is used for drawing down. The next is usually fitted with flat dies and is used for the roughing out or bending dies, while the largest is the stamping hammer proper.

The top dies in these hammers are dovetailed into the tup, and fixed with keys and dowels. The bottom dies are tapered towards their base and are held in position by poppet pins. This allows for movement in all directions in order to register with the fixed top

die, and thus obviate the necessity of accurate machining on the sides, which is essential when both dies are keywayed.

In American practice, the hammers are all of the semi-automatic type. Of these, probably the board hammer is best known. The tup of this hammer is raised, not by means of ropes or belts, but by boards, these being made of maple wood. The boards are fixed to the hammer tup by steel wedges, and at the top of the hammer pass between steel rollers, rotating in opposite directions. By pressing the pedal, the rollers are made to engage with the board and so raise it, until a peg on the tup strikes a trip, the position of which can be adjusted. This throws the rollers out of engagement, and the tup falls freely. When near the bottom of its stroke, the tup strikes another trip and throws the rollers into engagement again. This action continues automatically as long as the pedal is pressed down. In this hammer, both top and bottom dies are keywayed, and it is therefore essential that the impressions shall be very carefully located with reference to the sides of the die. The dies are of the multiple impression type, the roughing out and finishing operations usually being carried out in the one pair of dies. For medium and small work, requiring impressions which are not too deep, these hammers work very well, and are quicker in action than the steam or friction lifts. They have one disadvantage however, in that it is very difficult to vary the force of the blow.

The steam drop hammer is also very popular in the United States, when larger work is to be produced. The force of the gravitation blow is increased by the extra velocity exerted by the steam pressure. The force of the blow can be varied at will by the operator by varying the pressure on the pedal. Multiple impression dies are also used on these hammers, keyed both top and bottom. Steam drop hammers require wooden baulks to support the anvil block, otherwise the piston rods would be liable to fracture frequently owing to the constant jarring.

In the case of the English type of drop hammers, as previously mentioned, the anvil block rests directly on the concrete bed, thus forming an absolutely solid foundation. The reaction of the blow is practically all transmitted to the bottom die, and thence to the hammer, passing through the forging. This causes a tendency for the steel to run up into the impression, and it is noticeable that a deep impression is filled in the top die before the bottom impression is completely filled. With hammers having a yielding foundation of timber, the effect is somewhat different. The blow is partly absorbed by the foundations, and there is little reaction to the tup. The blow is thus manifested more as a squeezing action from the top die, and deep impressions are not as easily filled as in the case of hammers with the solid base.

Furnaces.

The heating of steel billets for forging is a problem which presents some difficulties. Theoretically, the billets should be heated up slowly from a low temperature, but in practice it is impossible to achieve this ideal. Three types of furnaces are in general use, coke, coal and oil fired. The coke furnaces are modifications of the blacksmith's hearth, and require very careful watching when high carbon and alloy steels are being forged. Billets which are too near the blast are apt to be locally overheated. In some of the most modern works, the furnaces for the heavy hammers are coal fired, and are of such a length that a graduated heat can be obtained. The waste heat is conducted to overhead boilers, which raise the steam for the steam lifts. The batteries are thus self contained. Oil-fired furnaces are now largely replacing the coke and coal furnaces. They are much more flexible in operation, and their use results in a reduction of smoke and dirt.

Stamping Operations.

When considering the manufacture of any particular pattern, we must decide on the size of steel to be used. This depends on the largest section of the forging which has to be made. The steel is heated to a temperature in the neighbourhood of 1,000° C., and a " use " or rough forging is first prepared by drawing under the dummy tools, and if necessary flattening and shaping under the roughing hammer. The " use " is now reheated if necessary, and placed in the dies, forging being carried out until impressions are filled, and the forging is of the required thickness. During this operation a certain amount of surplus metal flows between the dies forming a fin round the forging. This fin is also known as the " flash " or " scrap." This metal must, of course, be removed, and for this purpose clipping tools must be prepared. The clipping bed consists of a plate of steel about two inches thick, having a hole cut out the exact shape of the forging at the die line. The bed is relieved round the hole to form a cutting edge, and is suitably hardened. The punch is so made that it presses on the forging at places where it is least likely to cause distortion. The tools are fitted into eccentric presses operated by a lever or pedal.

During clipping, however carefully the tools may be designed and made, a certain amount of distortion nearly always occurs. The forgings are therefore lightly tapped in the dies to correct this. It is essential that this tapping shall be carried out as quickly as possible, particularly in the case of thin sections like connecting rods. If tapped cold, such articles, although they have commenced to contract, are again stretched to the original die length. Not having now to cool from the forging temperature, they do not shrink the full amount, the result being that they are too long.

Forging Machines.

The forging machine is particularly useful for patterns having parallel shanks with enlarged flanges. In principle the machine consists of two dies, one fixed and one moving, the impressions being cut horizontally, and grooves are sunk just capable of gripping the stock. The steel, after heating, is placed in the groove of the fixed die. On pressing down the actuating pedal, the moving die moves up to the fixed die, and at the same time a ram holding a machined punch comes forward. This punch forces the metal to fill up the impression, and in some cases part of the work has to run up into the punch.

After Treatment of Forgings.

All forgings are taken from the stamp shops to the inspection department, where careful examination is made for defects, which may have been present in the steel billets, or have been introduced during the making process. After inspection, the forgings are passed on to the heat treatment department, where they are hardened and tempered, normalised or annealed, according to the specification required.

Discussion.

THE CHAIRMAN, MR. A. H. LLOYD: I think we have all been delighted with this extraordinarily interesting paper. Each one of us, as production engineers, recognise that it has been of the utmost value. Our lecturer has taken us absolutely into his confidence, because not only has he told us about his successes, but he has also been very frank about his failures, and I think that adds to the value of the lecture. He has told us about the method of producing forgings with holes in. I have been disappointed at the comparative cost of forgings with holes in, as against pieces cut from the bar with the holes drilled. Perhaps Mr. Rowley can tell me where I am wrong. Dealing with the subject of drop hammers, there is one thing which seems to be debatable in your own practice. You talk about a foundation of sixteen feet of solid concrete, to provide a solid resistance to the "tup," but when going over some works in Belgium I came across drop hammers which had for this foundation a block of solid rubber, and you could literally see those bottom blocks bounce as they came up again. I should like Mr. Rowley's views on that practice. Mr. Rowley omitted to mention that it is quite a good practice to fire heating furnaces with pulverised fuel, which is considered to be even more economical than oil.

MR. ROWLEY: The cost of the forging mentioned by the Chairman would depend on the method of manufacture. Produced as an ordinary forging, the cost of the discarded flash and wad would,

of course, have to be taken into consideration. If made as a machine forging by upending, fairly expensive tools would be required, and to produce the pattern in question, an unusually large machine would have to be used.

THE CHAIRMAN: You suggest that the machines which would do that are rather limited.

MR. ROWLEY: Yes. With regard to the foundation of rubber, this to a considerable extent depends upon the type of hammer used. There is one in Germany which has a weight of two tons, picked up by a rod of about one inch diameter, and another which is shot up from the base by four pistons. I should like to know if it is one of these types.

THE CHAIRMAN: No, it is an ordinary drop hammer.

MR. ROWLEY: The rubber foundation is no doubt used to minimise the shock to the base block, but the use of such a resilient base is opposed to the accepted English practice. Much of the useful reaction would be lost with such a base. I regret that I failed to mention pulverised fuel. This method of heating is actually in use in rolling mills where billets exactly similar to those used for drop forgings are heated for re-rolling.

MR. CROWTHER: I must express my appreciation of the very excellent paper I have heard, and I should like Mr. Rowley to differentiate between drop stampings and drop forgings. Mr. Rowley has described three methods of forging—upending, rolling and stamping. Can we take it that the difference between the last two methods and the difference between the flash in the die is that in the rolling method the flash is parallel with the axis, and in the stamping method at right angles?

MR. ROWLEY: I am afraid I have been rather slack. The correct term is "drop forgings" although the men engaged on the work are called stampers. As to methods, there is not a die line proper in the rolling method which is really a swaging method. You have a pair of dies which are very much rounded at the edges and the job is made by turning the bar, this being similar to the blacksmiths' method.

MR. THOMPSON: I had better drop a brick to start with. I think that it is fairly accurate to say that the forgings generally produced in the United States are in advance of those produced in England. The matter of introducing three-die sinkings in one die blank I consider wrong, although a very large field is open to the stamper in following machine-shop practice of doing a job in a series of operations. In the case of connecting rods, it is very necessary with present-day engines that the rods should all be of the same weight. If you do not get this approximately right in the stamping it causes a lot of work in the machine shop in order to get these rods interchangeable in case one breaks in the engine and you have to replace it. If one rod is heavier or lighter than the

others in an engine, then you get vibration. I think these rods should be roughed and finished in a series of separate dies. I consider the matter of putting three-die sinkings in one die block likely to cause offset in the stamping, and is also very bad for the machine. The rods would be much better done in a series of separate dies. With regard to heating a job, you have pulverised fuel, coke, coal, and oil. I think that in heating these jobs the best forgings come from the muffle. I hope to see the day when we shall have electrical furnaces for these jobs, and we shall then be able to dispense with oil, coke or coal as fuels. Another point which concerns valves. We all know that there are millions of valves used, but the British stamping trade seems to have fallen steadily behind in valve forgings. Valves are being produced to-day with only sufficient material left on the forging for grinding purposes. I would like to mention with regard to connecting rods, that this method of several dies has been used with great success in conjunction with separate furnaces.

MR. ROWLEY: You threw a brick at me, and now I am going to throw one at you. You open by saying that the United States is far ahead of us, and then in the next breath you say that the United States' methods are no good. The multiple-impression die is an American method, and it is a method which is solely used in the United States. The question of getting a fine limit is one which is of very vital importance, but I do not quite know to what limits the machinists require a connecting rod to be forged. I will take as an example a steel rod, weighing approximately eight pounds which is made to a margin of about four ounces. I do not think that a matter of four ounces in eight pounds could be called a great variation. To work to finer limits would result in a much more expensive job. It is impossible to use three highly expensive hammers to produce a job which would sell at about tenpence. The plant would probably cost £3,000, and in addition would entail the attention of six to nine men in tending it. Connecting rods are being produced in thousands with no greater variation in thickness than one millimetre. We do, in some instances, work to ten thousandths, which is a very fine limit for a forging, but this, of course, is only in very special cases. The question of heating is a vexed one. I will agree that electrical heating is the ideal, and the best form if we could only get it at a competitive price would be the high frequency electric method. That, in my opinion, is the really effective method, because it heats from inside as well as outside. The firm with which I am connected does not manufacture valves, but I believe that the price of valves is very finely cut. The production of valves to the fine limits suggested would require the use of very expensive tools. There is a new method used in France which only heats the stock locally, and this is reported to give a valve to much finer limits than the methods in use generally.

THE CHAIRMAN : I want to interpolate a word or two here. I think it is almost obvious to everyone that heating electrically can never compare in cost with heating by other methods, because your current has to be generated, coal has to be converted into steam and steam into electrical power, and at each stage you are losing in efficiency so that in the long run composite fuel must be cheaper than heating by electricity.

MR. E. W. HANCOCK : I was very interested in Mr. Thompson's remarks regarding American stampings, and as a result of my investigations in America on this subject, I would agree with him that for motor-car production American stampings appear to be more accurate and more consistent than those we generally receive in this country. The cost to production of inconsistent stampings can be considerable, as although stampings may not be quite correct to drawing, a consistent error can be dealt with by modifying the special equipment accordingly, but where inconsistencies arise, this then becomes quite a costly process. Whether the American stampers use more sets of dies for any one stamping, and re-heat more times than we normally do in this country, or not, I do not know, but since the ultimate price of the finished article is lower than our price in this country, it would appear that any extra cost of the stampings themselves is justified. I would ask Mr. Rowley what is the largest size of brake shoes stamped in pairs he considers to be a reasonable stamping.

MR. ROWLEY : I am not going to agree that in general drop forgings made in the United States are better than those made here. I am only going on my own experience of those that I have handled, and I must say that the general quality was very much below that required by the English market. In America they are counting in thousands and tens of thousands, while the average English manufacturer orders in hundreds, and sometimes in dozens. The money which you can afford on plant and dies for jobs which come in in hundreds is very different from what you can afford on plant and dies for hundreds of thousands, especially when the former may not be repeated within the year. The cost of dies is an important factor. You may have over £100 sunk in steel alone, then you have the work on the die, which may take three weeks to sink. There is the risk that the die-block may break on the first stamping you make. It may last five hundred, it may last a thousand, or it may not last one. That risk has to be covered. If you are going to produce in tens of thousands you can afford to cover that risk. The largest diameter brake shoes which it would be economical to make double would be about twelve inches. If you were to go beyond that it would not pay. Actually, brake shoes are better if made in two halves, because the bar can be bent to the shape of the shoe, whereas with the other method you get a certain amount of cross-grain, and also more waste.

MR. AIERS: At the beginning of the lecture Mr. Rowley mentioned some wrought iron forgings which obtained from the Roman site at Stratford-on-Avon. I could not see from here whether they were rusty. If not, has he analysed them and found them to be purer than iron than that at the present time? As regards electrical heating for furnaces, we have taken tests and we find that with electricity it is only half the cost of gas, taking electricity at three farthings per unit and gas at 2/11 per thousand feet. Would Mr. Rowley give us some limits of the upending process? We have had discussions on the limits of stampings. I can give an instance where we have had to sort stampings into three different lots before we dare put them on the machine. Take a simple thing like a flywheel. We have had them from three different firms. We sent a gauge and a sample, and told them to work one sixteenth and then we gave them an extra one thirty-second, but they told us that they must have at least one-eighth of an inch. Mr. Rowley has shown us that there are a lot of defects in stampings. Usually we don't get them, the only thing we do get is what they call from habit "pitting." We call it something stronger than that, and the machine people say even worse than that. These are the defects we usually get except in one case, where the metal which tends to flow upwards, as in a deep boss. We have had trouble there, because when the boss flows up the metal is sucked up on the other side, leaving a cavity, and then you have to use a single point tool before commencing boiling.

MR. ROWLEY: The wrought iron of the Romans is quite as good as the wrought iron you can buy to-day, in fact it is better than some. There was also some cast iron found there. Most experts tell us that the Romans could not make cast iron, but it was proved to me quite conclusively that no one could have placed the cast iron there, in fact it was found amongst broken crockery bearing Roman marks. We use electric furnaces for duralumin work, but I don't think electric furnaces for ordinary forge heating are a practical proposition at present. In upending you are limited at the start by the amount of metal you can gather up. You cannot "bump" up more than a certain length for any given diameter at any one time, otherwise corkscrewing results. I have heard of a great deal of trouble being experienced through variations in flywheels, but there is no reason why they should not be made to an eighth. It is quite possible to work to less than that, depending upon size.

On the motion of Mr. Hancock a hearty vote of thanks was given to Mr. Rowley for his lecture.

COSTING AS AN AID TO PRODUCTION.

Address given to the Institution, Birmingham Section, December 18th, 1929, by P. H. Lightbody.

THE subject of my address this evening is divided under two headings: (1) Costs in relation to selling prices, and (2) Costs in relation to production, and how costs help to reduce cost.

I would like to preface my remarks with a few statements of elementary truth, and may perhaps be pardoned for doing this, but as there are always younger members of any Institute, it is just as well to show these where we are going.

The primary object of business is to make a profit. It is not reasonable to expect a profit for oneself only. All desire this. The greater the spending power of the people, the more goods they can buy and we can best achieve our end by reducing the ultimate prices of goods based on cost reduction. If at the time we reduce costs we can increase wages, then we have doubly added to the prosperity of the multitude. Much more could be sold if people could buy. Nearly every one desires some product that he cannot purchase, due to lack of funds. Many get little more than the bare necessities of life, due to a large extent to the lack of managerial capacity on the part of men sitting in control jobs.

Financial deals making for redistribution of wealth would not give us the desired result, which, to my mind, can only be obtained by reduced costs and lower selling prices. Combines or cartels started for any other purpose than this seek to refute a natural economic law. Other things being equal, if we raise the cost of an article or a service, with an ultimate increase in the selling price, we narrow the field for distribution. Other things being equal, if we reduce the cost of an article or a service, with an ultimate decrease in selling price, we widen the field of distribution. It is assumed that we do not look with favour on extortion by market control, and that we are willing to meet the economic laws of supply and demand which must eventually obtain, taking industry as a whole.

U.K. Practice behind that of U.S.A.

I am asked this evening to address this meeting on the value of cost data as an aid to productive efficiency, and since I have recently returned from the U.S.A., where I visited many industrial concerns, I am supposed to be in a position to give you the answer to anything and everything. May be, at this stage, it will not

be out of place if I refer to what appears, to my mind, to be the fundamental difference in viewpoint on cost data between this country and the U.S.A.

Cost accounting knowledge in this country is not behind that of the U.S.A., but the use or application of cost knowledge is very much behind that of the U.S.A. That, gentlemen, is just where the trouble lies. It is very little use making accurate and very expensive gauges and tools if they are kept to look at. Tools, in the physical sense or otherwise, interest me just so far as they further efficiency. Costs are the tools of management. I am fortunate in having had access to many industrial concerns in this country, and, speaking generally and honestly, must state that many of them look upon the collection of cost data as a necessary clerical operation used generally for comparing with sales or previous performance.

It may be necessary to make a distinction in industry between these concerns making a repetition product and those making single units. I purposely use the word distinction here rather than difference.

Costs are the raw material for efficiency. No industrial operation or function has reached its highest efficiency or its lowest cost. Intensive investigation leads to new methods. Let us take for our slogan "Good Enough is an Enemy of the Best" and proceed to gather cost data with a view to using it. In the first place we want cost data quickly. Unless we can have this we shall have to deal with the past instead of the present, and secondly, we want one whole time man or more whose one object in business is to look for better methods.

Assuming that we have to investigate a business at present running, making a profit or not, as the case may be, we must first build up a plan and then refer the present personnel to it. The purely financial end may need first attention. May we assume that this can be left out for the present? It must in any case come into the picture during the investigation. When a conjurer has only two really good tricks in his basket, he hands one out at the beginning and saves the other for the end—he starts off well and tries to finish well. Maybe we have no beginning and no end in this sense, but it is advisable to take a fruitful avenue first, so that we may have a victory to start with.

"Non-Productive" Costs.

A never failing source of cost reduction lies in the direction of what are called non-productive costs, one item of which is handling. Possibly we cannot get any cost figures on this. Cost figures of this kind may be buried in the expense account or located in such a way that we cannot isolate them. Failing to obtain handling costs for past periods, we may need to make a survey of handling—

tracing the product through from receipt of raw material to the final delivery of the finished goods. We may then arrange to collect the cost data of each function, and still collect our product costs as before. Employees who are misnamed non-producers can split their time under the approved headings of handling, sweeping, scrap removal, etc.

Production Costs.

So-called production employees can allocate their expenses under two headings: (1) Direct to manufacturing operations on one job, and (2) Direct to one of the divisional headings arranged for non-producers.

May we pass over the time necessary to collect the cost data and assume that we have now obtained over a period sufficient data to justify action?

Standard Burden: Fluctuating Burden.

Costs should be collected under at least two main headings: (1) Standard burden; that is, material, labour and definite overhead; and (2) Fluctuating burden, that is, the deficit or surplus on the standard rates, due to short time or overtime, etc.

My cost of sales account should give me, every fiscal period (say, four weeks) a summary of costs under the two headings referred to, that is, standard and fluctuating burden. This can be obtained, if desired, for each sale, product, group of products, district or salesman. The selling prices of all lines sold during the period are summarised under the same headings as the cost of sales. This shows me where I am losing, and where I am gaining profits—on which line, order, district or salesman, and how much I have gained or lost over my standard burden and how much is due to short time or overtime, and where my sales force can concentrate. I am also able to judge, assuming price to be the great factor, how much less I will accept for extra business to absorb my deficit in burden, and how much more surplus burden I can accrue by adding to my present output. I must bear in mind that the market price will ultimately be fixed by the economic law of supply and demand and that I should endeavour to be the first to reduce the price, not the other man, assuming a legitimate basis for my reduction.

I will now turn to the second and chief heading of my address—costs in relation to production, and how cost information helps to reduce costs. My previous remarks refer to the position where costs are not available. I assume now that costs are available for each function or operation and component.

Invoicing, Handling, etc.

My first investigation may be along the line of function. Maybe I will start in the office. Now, how much does my invoicing

cost? How many invoices are issued per period? What is my cost per invoice or per line on an invoice? The same question arises with my purchase invoices, my sales invoices, my ledgers, etc. What is my unit cost? How is the work performed? How can I reorganise it, not forgetting the cost of obtaining my costs. Assume that my invoice cost may average one shilling per invoice, the principal item of which is labour. I may be startled to know that the invoice costs 1s. to issue—probably very much more. I may never have looked at my invoicing costs on a unit basis. If not, I will probably get a shock. Invoicing costs were probably lost in my office expenses. The same remarks apply to all my clerical services. I know now where to attack my clerical costs and by careful planning can generally make a considerable saving.

My next attack may be on so-called non-productive work, including handling, trucking, storing, cleaning, sweeping, supervision, etc. Take the first item only. What is the total cost of handling? How is it done? Where are my stores? How can I arrange this work to use conveyors, electric trucks, etc.? Can I arrange an even flow of work, can I begin my operations at the top of the building and use the law of gravity to aid in their dispatch to the floor below? In this connection it may be useful to mention that a large number of concerns start operations on the ground floor because material arrives there, when by elevating material to the top floor immediately it is received, a great deal of handling expenses would automatically be avoided.

Direct Production Costs.

We now turn to direct production, finding the time and cost of each operation performed under our agreed cost heading. We begin our investigation with a full record of performance, amount and value of material used, cost per operation for setting up and making.

It is necessary to take our cost figures to the job. However much you know of manufacture, do not fail to take your cost figures into the shop, alongside the job. Do not always think of past performance and present performance. Look at your cost figures whilst the job is in progress. Study the job and the cost together. You may find it makes a very great difference to the result. None of us is sufficiently observant. We are all apt to take things for granted. How many of this audience can tell me the number of steps from the hall in their own homes to their bedroom, and how many know the pattern and colour of the necktie they are wearing? These points may appear irrelevant, but they tend to show an everyday weakness. It is not enough to take average speeds. Averages may prove a curse. We are not working under average conditions, but under individual conditions, and therefore an average may often mislead. Look at the best performance and

the worst. Get some ideas from that if you will, but do not forget that the best performance may not be good for long.

Gather your costs regularly and with an eye on the job. Think of means to reduce these costs anywhere you can. New machines, new tools, different designs, different lay-out, faster or slower speeds—always bearing in mind that the faster speed may be the more expensive. The end we have in view is the reduction of cost with an ultimate reduction in selling price. Prosperity for the many may mean nothing less, if nothing more, than a reduction in selling prices.

This subject of how cost information helps to reduce cost is a very wide one, and it is not possible to do more than touch on it in an evening.

Since perhaps you may be thinking that I generalise too much, specific applications not having had attention, I will now refer to one or two sources of gain from the use of cost information.

A "Telegram System."

The first will be a system in use in my company's works and known as the "Telegram system." The aim of this system is to prevent as far as possible losses of bonus both to the operator and to the company. Standard times are fixed for most jobs, and the tools, materials and the job or drawing are available beside the worker before his last job is completed.

The worker clocks on to the job which, for the sake of argument, takes thirty-two hours or four standard days of eight hours each. The cost collecting sheet was originated at the same time that the job order was made for the worker. This cost collecting sheet gives the standard time for the job and is in the possession of the works cost office.

Twice each day a cost collector enters the time used on the cost sheet and makes an accumulated total. It is very easily seen how much time has been used on the job. When the time is used up the works telegram form is originated in duplicate by the cost office. One copy goes to the worker telling him of the amount of time used to date, the standard time and the excess. The other copy goes to the production manager for action. These telegrams are despatched twice daily until an inspection note arrives showing the job is complete. It is surprising how much has been saved by this simple method. In the first case, a worker does not like to have a visit from the telegram boy even once. Secondly, the production manager gets on to the job immediately and can see what the trouble has been, whether bad material, slow worker or whatever the case may be. If the job is a new one and the standard time appears too low, the production manager can get the time setter alongside the job whilst in operation. Even time setters make mistakes. To know that a job is losing money before

it is finished is worth much more than to know afterwards.

Re-Handling ; Standard Time.

Another source for considerable saving is the prevention of what I may perhaps term re-handling. By this I refer to breaking off a job before completion and in most cases the re-setting of the machine. Many of you will be familiar with the "rush" job or the pet job of some one that has to be done in a hurry. If a machine is stopped before a job is finished because some one just thinks a new job is urgent, we must waste time. Without going into details on any particular planning system, I say that no job, once on the machine, should be taken off without the sanction of the works director, whether it be the works manager or not. It may be necessary to re-shuffle jobs so that one or a series of particular jobs get precedence, but no job should be taken off a machine before completion without a signed authorisation from the works chief.

In this connection, the following system may be of interest. A clock card is issued to the worker stating the standard time for a given task, and has a perforated stub at the top. This stub gives the standard number of hours for the job, the name, number and department. When the worker begins his task, he places the card in the time recorder and records the hour, minute, day and date of starting in the proper fields. He then turns the card upside down and records the same time on the stub, which is $3\frac{1}{2} \times 2''$. The worker tears off the stub and deposits this in a box alongside the recorder. Each hour during the working day, this box is cleared and the stubs taken to the control office where they are filed in a rack headed with the day of the month and the hour of the day, referring to the due finishing time for the job.

Assuming an eight-hour-day of eight to twelve and one to five, and a job for which the standard time is twenty-two hours, beginning on Tuesday at ten o'clock, twenty-two hours forward would bring us to ten o'clock on Friday. One full hour being allowed before action, at eleven o'clock on Friday morning, if the notification that the job has left the machine is not in the cost office, a chit similar to the telegram would be issued. Where a job has been taken off the machine with full sanction the job stub is suspended. Where operators work overtime, the overtime list is dealt with each morning and the job stubs are re-arranged under the new finishing times. When workers are absent the charge hand originates a change slip. It may be impracticable except in a very small works to inspect all jobs for excess time before the time allowed is used up, but it is very easy to get after a job immediately the time is used up. The police may not be able to prevent robbery in the direct sense, but they can endeavour to locate the offender before he gets too far away.

Management.

Whilst on this section of the subject, I do particularly want to stress the point of management. So many executives direct so much attention to the direct producer, that they have no time to look at the errors in management. On management rests the responsibility of the future. A man can be fit for control without any assurance that his son, who will probably take his place, is fit for anything in particular. A skilled tradesman must serve an apprenticeship at least, even if he is a failure at the end of it, but the son of his father walks into the business according to age. Some day, maybe, we will be able to select men for control jobs according to their ability. Our American cousins are much better off than we are in this direction.

Full Utilisation of Plant.

You, gentlemen, who are mostly production engineers, will be interested in the full utilisation of your plant. May I suggest that you collect your machine running hours under at least two headings: (1) Production; (2) Setting up. A machine is not directly producing when it is being set up any more than when it is idle for belt repairs. Both setting up and belt repairs may be necessary, but the less we have of them the better. It is very useful to have a summary of machine hours under the following headings:—(1) Normal or standard; (2) Running; (3) Setting; (4) Idle or repairs.

If we are waiting for some great break, some wonderful new idea in industry, we shall probably be unlucky. We must be prepared to build our lower costs like a house is built, little by little, and realise that the sum of our small savings may be considerable. Man is wasteful. It is only competition that keeps him in the right path, and the more straight competition we get, the better for all of us.

Sales.

It may not be out of place to touch on the selling question. Production is no use unless we have sales. Apply the same methods referred to in our attack on reduction of works costs of your products. What is the total cost of my sales last year? Which businesses or trades took more than £200, which £1,500, and so on? Which of these trades are the more profitable? What do these customers use the goods for? Where are there similar trades? Will it pay to have specialised salesmen for separate trades and so on? It is necessary to pioneer, not wait for the other fellow, but try to find new avenues for sales and to make a habit of looking for new avenues. They are often more profitable than the old where Tom, Dick and Harry are cutting each others throats in the old arena. We must get away from the herd instinct and pioneer. All businesses will not prosper. Apart from the necessity of getting a living there is a real joy to be obtained from

business. It is the creation of wealth that we industrialists must have in mind.

Wasteful Calculations.

The elimination of one quarter of the waste in industry in this country would soon pay off the national debt. Legislation cannot alter the mind of the people; that must come from a change internally. When Trades Unions are bargaining for terms, the question of costs should always be in the picture. Not that I am against increased wages or even reduced hours. Take the negotiations when the forty-seven hour week was created. Did it not occur to anyone that the week might have been arranged to be forty-eight hours, saving some millions of pounds annually in wage calculation? The average wage is not divisible by forty-seven. It would be divisible by forty-eight since 1s. per week of forty-eight hours is equal to one farthing per hour. This again, you may think, is a very little thing, but industry is built up of little things, and the cost of a locomotive includes an amount for wage calculation just in the same way as it does bolts and nuts, wheels and tires.

Expense Accounts.

I would like you to consider the question of issuing to the head of each department an expense account each period showing him not only the total expenses which he can help reduce, but the rate of expenses. For instance, to tell a foreman that he is debited with £10 for oil may not attract his attention in the least, but to tell him that he is charged with twenty gallons of oil at 5s., twenty gallons at 4s. 2d. and six gallons at 3s. may result in the 5s. oil dropping out of his requisitions. Give your subsidiary men an interest in the cost side of their charges and give them an incentive to cut out waste either by using cheaper products, which of course must be suitable, or employing different types of labour.

Your central purchasing office may be all right at bargaining about prices, but remember that the man on the job may have ideas. Reduction in waste is reduction in cost, whether it be material, clerical services, so-called non-productive labour or machining operations. The question of magnitude may attract you to a particular field, but do not leave out any item of expense, and do not forget that the great need is for management to manage, not by kicking those who occupy humble posts, but by leading in the true sense. Do not live only in your own business. See how other businesses do their job. A tannery manager could possibly get some excellent ideas from a laundry, and so on. No one business has all the knowledge or ideas. It is necessary to get a broad view of industry as a whole, and remember that good enough is an enemy of the best. It is not enough to leave the operator to improve on his time. Try to make the task lighter by research and

management and do not be frightened to look at problems in very great detail.

Exchange of Information.

I may perhaps refer to an incident during my recent visit to the U.S.A. I was talking to one of the chiefs of a very large concern in Detroit, when an assistant, in the usual unceremonious manner, "blew" into the office. "Say, chief," he said, "guess they got ahead of us across there," mentioning a certain firm. "They got a machine making 800 operations per hour against our 320." "The hell they have," replied the chief, and immediately put a call through to the production manager of the competitive company. This is the caller's part of the conversation. I could not, obviously, hear what the other speaker said: "Say, Bill, guess you have got a So-and-so machine making eight hundred operations per hour. How about it?" He paused for a few seconds whilst the man answered, then: "Right, I will come round and see how it is done." The chief then disappeared in a car to inspect the other man's new machine and returned in the afternoon before I left with notes sufficient to get his drawing-office on to the job to produce a similar machine. That, gentlemen, is the spirit to make a country great industrially. Much has been done by Institutions like yours to pool information, and much more I hope will be done. We must not keep industrial knowledge up our sleeves.

History, a Record of the Impossible.

A little incident comes back to my mind in reference to Signor Mussolini. A friend of mine was asked to see Mussolini on a certain project. Mussolini told him what he wanted to do, and my friend, who is a very able scientist and very well-known man on this particular problem, told Mussolini that it could not be done. Mussolini asked him a second time, but my friend answered: "It cannot be done, it is impossible." Before my friend left Mussolini he said: "Would you be good enough to write in my autograph book?" Mussolini did so. My friend was very much disturbed to read in his autograph book: "History is a record of the impossible." That, gentlemen, is something to think about.

Discussion.

MR. WRAY: I should like to ask Mr. Lightbody to give us more detail about this telegram system.

MR. LIGHTBODY: To go into this system would take too long, but I will be glad to hand you a booklet describing it.

MR. SWIFT: With reference to the telegram system, can you give us any idea of the total number of forms likely to be used at any given time in the works you spoke of?

MR. LIGHTBODY : The forms consist of an operating sheet, which would be needed in any case as a job order : the telegram itself, which is in duplicate and would cost 4s. 6d. per thousand, and the cost collecting sheet which you have normally in any case. The summary of losses of bonus for nine men prior to the adoption of this system was £89 10s. 9d. In the second year of the telegram system the loss was £38, and in the fourth year the same men's loss was £28, so there is a saving there of £60 on nine men, which, of a course, is an appreciable item for a large works. On a summary of years from 1920 to 1927, the average bonus earned was 3.35d. per man hour in 1920, in 1921 it was 5d., in 1922 5.18d., then 5.7d. 5.8d., then 6.3d., so from 3.3d. in 1920 the bonus was increased to 6.3d. bonus in 1927 with, of course, a consequential gain to the company.

MR. E. W. FIELD : Was there any improvement in the methods of production in this period of years, because, if not, I think something should have been done in that direction ?

MR. LIGHTBODY : Yes, improvements take place regularly. It is very rarely that a job goes very long without being improved, but as you know, when improvements in design take place or different methods of production, the time is re-set, and these are always on the set time, although the time itself is considerably reduced.

MR. H. C. ARMITAGE : Referring to the telegram system, you stated that the summary of losses of bonus for nine men was £89 the first year, £38 the second year. Did you have an analysis of what the costs of these lines were in each year ?

MR. LIGHTBODY : Yes, but I am sorry to say that I have not the costs of the lines on hand. We keep these costs with the object of assisting the production department, so that they can get right on to a job at once, and able to do something. There are men who will take bad material and work on it and say nothing. In this case, if the material is bad it is taken away. Anything wrong with the machine or the tools is looked at right away. We can only take care of this sort of thing when the time is used up, but even that is better than much later on. These figures that I give you are taken right from our records. We just took nine men who were with us in 1920. As you know, in many workshops there is a good deal of joking goes on, and the telegram boy is made rather conspicuous by a peculiar hat, and when he takes a telegram to a man all the people about who have half-a-minute, do not forget to say something.

THE PRESIDENT, MR. J. A. HANNAY : In Mr. Lightbody's address he spoke of costs being wanted for the present, not for the past. I think we agree with him. I do not know any concern that I have been with that could not give you the cost up-to-date, or could not tell you what you were doing almost on the day you were

doing it. Waste : I feel that that is the cause of the bad situation in many big industrial concerns to-day. It is only when some one with authority in some department can have the information at hand to be able to use it quickly before much money is wasted. I should like Mr. Lightbody to say another word or two, if he will, on how to get the costs quickly to the producing department. Mr. Lightbody has referred to his visit to America. Many wonderful things are done in America. They must have a wonderful control of the costs to be able to produce records as they do. There is one thing that struck me particularly when I was there, which I could not reconcile with their business methods, and that was the terrible extravagance of the ordinary man. I should like to know if Mr. Lightbody noticed that, and if he can reconcile that with business ? I should also like him to give us a word or two about the systems of American cost accountants. Some of their costs are really marvellous. We make things in this country—we think we have got down to rock-bottom. I am just thinking of an article that is made in this country for from £30 to £40. It goes to America to be put on the market there, and they talk of making it for about £6. We could not find our material for three times the price. There is another item that I think Mr. Lightbody will be able to say something definite about, and that is scrap accounts. How to get the information about losses through scrap and defective work down to the people responsible and in such a form that the people in the shop can take an intelligent interest in it, and in the case of a big concern, where comparisons can be made between the various departments. I did not notice a single reference by Mr. Lightbody to mechanical accounting. When a business gets to a considerable size, it is my personal view that you are entirely out-of-date unless you employ mechanical means to assist you with your costs. I do not think that a big concern can possibly collect information in time to be of any use to the people who are producing and working without this. I am sure there must be some one in the audience who has had some experience in that line, and I would invite him to give us his experience. I saw a letter a few days ago from a gentleman who travels a good deal and had been looking up the doings of some of the Continental and American machine tool makers, and I was very sorry to see it stated that we are dropping back in this country by comparison. As our whole success depends upon improving our methods, our tools and lathes in the shop, so I am convinced that our cost accountants and all those dealing with that side of business, will have to use mechanical means so that they can bring the information absolutely up-to-date.

Mr. Lightbody : The chairman asks me to say a few words as to how we can get costs quickly, and that brings forward the whole question of cost data. I will, if I may, couple that question with

another one that the chairman referred to, and that was, American costs. Now, the two are the same thing. The difference—not the distinction—between the American methods and ours is just this, that most of us in this country make some drawings, send the things out into the shop, and take the cost of them, and there it is. May I refer you to a very illuminating incident that occurred to me in the works of a large motor car factory in Detroit. I spent two days there. The controller of the American factory is a personal friend of mine, and just about this time they were about to put on the market a new car, which is a sort of cheap edition of another model, and I went through all those figures with him. They had never "manufactured" this model. They had made a couple by toolroom methods, but had never manufactured them by production methods. Their leaflets, catalogues and lists were already printed, with prices. They told me exactly how much they were going to make out of that car if it sold. I did know their methods fairly well, but I was just a little startled, and I spent a whole afternoon going through the lay-out not only of the plant but the costs, and the whole story. Some of the parts that go to make up this new car are parts that are already being made for some other car, but many parts, for instance the back axle, was new and of much lighter construction than that in the other model. They had been on the time setting and production study of this job for two months, and they had predetermined not only the time but the burden, the cost of material and everything on every one of the single operations of that car and its assembly. They had determined the exact discount they would give to the dealer and everything about it. Now, gentlemen, it takes a lot of hard work before one can predetermine to within a few cents the cost of a complete motor car, and it was an eye-opener to me. But the difference between the net price on this (list price less discount, less selling expenses) was just sufficient to allow them twenty-two dollars per motor car. It is quite clear then that if the margin they were expecting was only twenty-two dollars, there is no room for much guesswork. That is predetermination to a fine point. If we are going to compete successfully with many of the industries in the U.S.A., if we cannot do something better than they are doing, the best thing is for us to copy them. These few words, I hope, will take care of that point. With regard to scrap. Part of their incentive plan takes charge of scrap. They have a corps, very nearly a small army of inspectors, to inspect the material when it comes in. Not one-hundredth part of one per cent. of faulty material gets into work. Another thing that struck me was this. One of their indents called for 127 tons of a certain class of material to be delivered at their works at four o'clock every day; not 4-10 or 3-59, and at four o'clock precisely every day that material arrived and it was stored away by five o'clock

and issued in the morning for the next job. They dealt with the man they were buying from under a penalty clause to deliver at four o'clock and believe me, if he had come at 4-10 they would have called the penalty. They use mechanical costing very largely indeed. It may interest you to know that I used a comptometer last century. Most of the mechanical devices are used in this country, but there is one that is not used in this country yet, though I understand they were just about to open a selling branch in Great Britain, and it is made by a cash register company. It is not a cash register, it is a book keeping machine. As many of you know, the hotels in America are probably the first hotels in the world. I have travelled round the world a little and though I have lived in many hotels, I have never yet lived in hotels where the service was so excellent as in the hotels in U.S.A. I stayed for two weeks in the Hotel Pennsylvania in New York, where they have 2,800 suites. In the ordinary way, they must do a lot of accounting and they did their accounting by machinery. These book-keeping machines, which look like big cash registers (they are about three feet by two feet in plan) have a sort of loose leaf sheet for every bedroom and each morning they place these sheets in the machine which debits to their account the proper sum for the room for the night, and puts into the various columns the amounts for meals, restaurant, or whatever it is, and accumulates the total. It also puts the total on a duplicate at the bottom, and at any time, if you are in a hurry and want to catch your train, you can walk right in that control office and get your bill in five seconds. The Hotel Pennsylvania uses four to six of these machines, and all the big hotels use one to six. That is the only new thing I saw over there. The ordinary tabulating machines are quite well-known in this country. The first question the chairman put, and which I attempted to incorporate with the question of predetermination of costs, was the question of obtaining these costs quickly. One must think of that problem in this way. Why do you want to obtain your cost information quickly? Obviously because you want to make use of it. Now you cannot make use of cost information until it is worth something to you, and you must know then one or two things about your cost information. One is that the work has exceeded its time, or has cost too much. If you have five hundred men in a workshop you cannot be going round every five minutes to see if the men are keeping up the required production. There must be some point at which you can make your investigations, and I say the only reasonable time to make that investigation is when a man has used up the time allowed him for the job. If you will adopt that method that I propounded to you to-night and issue a clock card with a stub at the top, and, when the man clocks on to his job, to clock on to the stub end at the same time, tear that stub off and put it in the

box, that stub will call attention to all your costs after the point of excess time. If there is no excess time, then you have no need to bother about your cost. From a cost-keeping point of view, you are only interested in your predetermined costs when they get beyond certain limits.

MR. J. BELL : The question of rapid information is of tremendous interest to all Production Engineers. On the lecturer's point in regard to the time when it is spent being the only time when investigations should take place, this does not necessarily follow with defective material, and as we all know, it is quite possible for a complete batch to run through in defective material and be entirely scrap. I would like to know if he has any suggestions to supersede our usual methods of floor inspection, or split orders, getting over that? As to the determination of costs for a new model, and selling prices, we must admit that the Americans are very far ahead of us. The time taken by them must be obviously in the nature of months and years as Mr. Lightbody has stated, and I am afraid that with us it very often becomes a matter of days and weeks. In fact, in some cases it is hours. I have been asked personally to give complete production costs for machinery required to be made and every particular for the production of a car from the raw material right to the finished article, and it was thought that a week was too much for the job. This, I think, will illustrate the difference between English and American methods. The job can be done if time will be given, and our British method, unfortunately, has been in the past to decide, say (in one particular section of engineering at any rate) two months before the show, what the model was to be, have the first models in the show and leave the rest to guesswork. With regard to Mr. Lightbody's remarks about delivery times of material, I very much doubt if any suppliers in this country would take on a contract on those terms.

MR. LIGHTBODY : In reply to your question about spoiled work, the idea is to isolate the problems. To my mind, the machine operator has not a lot to do with spoiled work. There are certain cases where he may have, but if you are thinking of spoiled work due to bad material, obviously that has nothing to do with the man, but goes back to the material inspector. In the system I was outlining to you, of which, of course, one can only take one section in an evening—and I took the machine section—the man has a given task to do in a given time ; if he does that task then other matters have nothing to do with him. The question of his spoiling the work, of course, comes into the picture, because instead of producing one hundred articles he may have only turned out, say, ninety. If I may diverge for a moment, I may perhaps refer you to a little dodge that is quite successful, and that is, in a great many works the question at issue is not so much money as it is time—they deal in time. If you are dealing in time, it is a very

good plan to order your parts in the shops in multiples of sixty, since, if you order sixty or multiples of sixty, the number of hours is immediately turned into minutes and seconds. If we have about 250 parts to order, we may order 240, which is four times sixty. Taking the time to be eighty hours in all, that is obviously twenty minutes each.

MR. R. H. YOUNGASH: It is not customary at our meetings, but I should like to ask permission to tell you a little story. There was a class of boys set to write an essay on sheep, and one little chap devised something after this style: "Sheep are very useful animals, particularly to men. Their flesh we eat as food, and their wool is made into clothes, but the practice of cutting off sheep's tails is very cruel, and should not be permitted, as what God hath joined together, let no man put asunder." I listened this evening to Mr. Lightbody's lecture and I have to confess that I rapidly came to the conclusion that the title was wrong, and that the title should have been: "Production as an Aid to Costing," and not "Costing as an Aid to Production." I visualised, as the lecture went on, the Production Engineers' Institution merging into the Cost Accountants' Institute, and we being run by little slips of paper, boys with telegram messengers' hats, on roller skates, of course—and my mind went on a little further and saw that the clerks who ran the works were one-armed men, because they would be cheaper. Then Mr. Lightbody cut the sheep's tail off by saying that even rate fixers make mistakes! I want you to notice, gentlemen, that Mr. Lightbody avoided making rate fixing part of cost-accounting. That is to say, the blame must be on some one else. The question of management is rather a difficult one, and there are two schools that persist in this country. You have on the one hand the modern works with all the up-to-date appurtenances that one can purchase, and you still have on the other hand a number of very old-established institutions. They are institutions really because they are handed down from father to son both in management and in the workpeople, and these old places manage to get along in spite of all the competition that we have to-day with all these wonderful aids to production, and in many cases they pay equally good dividends. That goes to indicate that costing and cost records may be very useful, but it is just as well to see that they do not become our masters. The proper place for them is there, without any question, but we must remember that, after all, the production is the thing. I was very interested in Mr. Lightbody's remarks on American estimating and preparation of costs before they started to manufacture. It was a point that I had already made a note to raise, because the question of cost of production is very highly influenced by the question of design. If your design is of a complex nature, it is very difficult to make some other arrangement which would serve the same function

more cheaply. No effort on the part of the cost accountant or the works manager can possibly bring the thing down to economical production.

A VISITOR : I would like to ask Mr. Lightbody if he can give us some idea of what he would call 100 per cent. efficiency of machine hours ?

MR. LIGHTBODY : I must first of all, of course, ask you the particular machine you have in mind, because with, say, a punching machine or a press, particularly a multiple press, the so-called efficiency of hours is very low. It depends upon the type of machine you have to consider, and that is what I had in mind when I said that it was interesting to have analyses of these machine hours. Many concerns in this country and other countries take records of their machine running hours, but they only put down in some cases the actual hours that they are running, the time of the job. As you know, sometimes it costs a lot of money to pull a machine down to re-set it in certain cases, and that to my mind wants taking care of. If you look at a machine, assuming you are working forty-seven hours per week, you might find that the number of hours booked on production jobs was only thirty-eight. You might ask : " Where are the other nine hours ? " I had an experience some years ago in a large concern in London where they had about six hundred presses. They had not taken any record at all of the machine hours. Each man in the department ran his machine to his so-called best advantage. I spent a couple of weeks in these works and then went away for three months. In the meantime a record was kept of all the hours on these machines under analysed headings of actual production, setting up, stopping due to broken punches. (They were using multiple fixed punches with as many as forty to sixty punches on one slide). It was very interesting to me to find that the average so-called efficiency of hours, taking the standard number of day hours at one hundred, was only 38 per cent. In other words, for 62 per cent. of the time these machines were forced to be idle. Now this was some information they had never had before, and they were about to add forty new presses because their press plant was not sufficient to tackle the orders they had in hand. From that investigation came to light very useful data. The chief reason that these machines were idle for 62 per cent. of their time was this : that it was not practicable for them to punch so many holes at once. If a punch broke, if there were sixty, fifty-nine of them were idle because the other fellow was broken. They put a special machine on one side and tried it out for some weeks, then changed their ideas altogether. Instead of very expensive machines, they changed them to put one hole in at a time and put it in very rapidly, and that was done through that investigation.

MR. J. W. E. AIDNEY : Just recently we have gone in for mul-

tiple presses, and we have taken the net efficiency and that efficiency has worked out recently at anything from 55 per cent. to 70 per cent., that is, taking the hours of work putting through batches of ten to twenty-five thousand. Another thing I was rather interested in, is the stub system. I have in mind the possibilities of working that with the planning system, and I should be glad if Mr. Lightbody would give us some details of what the average times are in his experience, and the average wage and what time it takes him to collect that information ?

MR. LIGHTBODY : I think perhaps your question is best answered by a reference to a proper planning system. I do not mean a system that is in use for nothing else but the production of innumerable forms, but a real planning system that has in view increased profits and benefits to the people in the works. I think you can work it out about 1.2 clerks per one hundred employees. That takes the whole of the planning and the control of the works. I took these figures out from three separate industries, using the same system, which I believe is the right one. I see very many systems which take hundreds of persons working hard all day producing thousands of bits of paper that nobody ever looks at. I think you will find that the tag system is the simplest and most effective device for the purpose for which it is intended.

MR. WRAY : With reference to 1.2 clerks per hundred employees, do you mean the whole of the employees or those in the works only ?

MR. LIGHTBODY replied that his figures probably referred to the whole of the employees, though the percentage on the employees in the works only would work out at a very small fraction more than 1.2 per cent.

MR. A. PERRY-KEENE : The lecture which Mr. Lightbody has given to-night is of extreme interest to all of us. You Production Engineers might like to hear my view, since I have had forty years of engineering and accounting practice. Forty years ago we used to forge our own tools and then find some grinding wheel and grind them up, and then we used to proceed to the milling machine or lathe and then it often broke. We had not a cutting steel sufficiently good to stand up to the work. We had very poor materials for making our tools and no means of making tools of any accuracy. To-day, we have extremely fine materials which we have coupled with extremely fine tools, and, aided by wonderful coolants, we can work at very much higher speeds. You have done that. But do not run away with the thought that the works accountant has not also come forward. Forty years ago the cost accountant was generally under the thumb of the managing director, who told him what to do. To-day, he is a man of very considerable status, and since the War a large amount of development has taken place from many angles. It has always been recognised that there

is no sentence so dread as a death sentence. The words: "Your cost of production is too high," is a virtual death sentence. We have, since the War, developed in England, in America and in Europe, electrically-driven accounting machines that can analyse an extraordinary amount of detail in a very short time. I have in mind a plant which I look at every day, a machine making 210 complete accounts or verdicts per minute. It is aided by a number of calculating machines that will do up to two hundred sums per minute per operator. Under these conditions we find ourselves in a position to look into a very near future in which we shall positively be able to see definitely what a job is costing to make while it is being done, not after it is done. One of the most important points, which has not been brought out so far, is the amazing number of supervisors in some American factories. Out of the total personnel—that is the works personnel, operators and so-called non-producers—in one large works I have in mind, no less than 42 per cent. of its personnel are doing service work, either gathering information, preparing material and seeing that everything is right and ready for the workmen. Nature gives us our material just as free of cost as the air, but material becomes expensive because we add to it the cost of labour. Therefore, there is only one big way in which we can reduce costs, that is by saving that time which is attached to the costless material. It has been clearly recognised to-day, I think, by a lot of the executive boards of large companies, and that is why they are prepared to put their cost accountants into the position where they can collaborate directly with the production department. We have nearly got to this position, and we can do it, almost, to-day, when we shall be able to give the expenditure, before ever the work is started, whether motor car or engine, not only material and labour cost, but profit, on-cost and everything relative to that particular article, We shall put you in a position where labour and capital must conform to these figures and make that particular article within that amount or they perish. If you cannot work, as engineers, to these particular figures, you will never be in a position to gain the market and achieve a basis on which you can really compete with other nations. We are developing along all sorts of lines quietly, and in another ten years I think you will see another class of accountant arising, able to hold his own in any engineering problem that may arise. Where the accountancy job lost in the past is that the right sort of people have not been employed. They have been purely clerical and not had sufficient training in the engineering side of the industry, and that has brought about the position where the engineer has laughed at the figures put up by the cost accountant. If the cost accountant was a man who had been through the works and assimilated the whole problem from end to end as to the correct cost of production, and able to show

to the superintendent of production the actual figures relative to the particular piece you are making, we should all of us be in a position where we could doubtless compete with America. Accountancy has developed rapidly during the last twenty years along that particular line. Mr. Lightbody has given us many illustrations of costs from various angles as he has seen it, but before closing I should like to assure you from my experience, which is no small one, that I consider the British executives, if they can only get together and collaborate as between costs and production, are able to compete with any nation in the world.

MR. PEARSON said he agreed with the last speaker entirely, but would go still further and say that the Production Engineer must be an accountant; in fact, he was not sure that the Production Engineer was not an accountant to-day. He would like to know what Mr. Lightbody meant by the two main headings of Definite and Fluctuating costs of production? Also he would like the Institution to turn its attention to the other side of the picture and to deal with costs from the viewpoint of a small production concern, as many present would be members, as he was, of quite small companies.

MR. LIGHTBODY: I think I can perhaps answer your question by stating that cost data is a tool of management. It does not mean to be a weapon, it does not mean to be a hindrance. The reason I stressed the point of dividing your costs under at least two main headings was this. Take a factory with one hundred men in it, for the sake of argument. Take the same factory with one hundred jobs in it, at work at the same time. One man does a job in four hours. It costs, say, with materials and overhead expenses, £1. That man comes along and does precisely the same job twelve months afterwards on the same machine, and it might cost 30s., because the other machines in the factory were idle and they were having to bear the burden of the unabsorbed charges. So that costs can be a tool of management. We must be able to show the cost under two headings at least. My reference to definite and fluctuating costs was this. Under the definite cost I have my material, labour and definite burden, which for the sake of argument may be based on machinery hour rates. My fluctuating charges, which are the deficit or surplus, may be due to working short time or overtime or anything else, have nothing to do with the direct production of that job, but the deficit and unabsorbed overcharges must be met in some way. They must either be a reduction of the so-called profit, or they must be added as overhead charge on the jobs that have been done. The definite cost should be compiled for purposes of production efficiency and the secondary cost wants to be looked at in quite another light, because that secondary cost may be entirely debitable to your

Sales Manager who could not get sufficient work to keep the factory running.

Mr. A. G. Brown said that even twelve or thirteen years ago, a friend of his told him he was able to lay before his directors at four o'clock a complete statement up to leaving time on the previous evening. He was very much interested in the question of machine efficiency.

Mr. Perry-Keene said the last speaker had raised a very interesting point. The great difference between thirteen years ago and to-day, generally speaking, was that where for £1 we could make one article, we have got to make possibly five or ten to get the same turnover.

Mr. W. G. Groocock : I beg to propose a hearty vote of thanks to Mr. Lightbody who has given us a lecture to-night on the essentials of works management, and many of the things he has said should be taken to heart, but I do not think he said quite enough about costs. Costing is so wide, its work is so varied, that it would have been very difficult for him to have dealt with the whole of it. You will agree with me when I say that he has dealt with it very well in the time at his disposal. He stressed the importance of time, and I agree that time is very important. Time is a thing to deal with first in the head office, but I think we can pay a man a definite price for a job, and in doing that I will go a step further and say that when that man has improved on that particular time that we have allowed him, then we should pay him something more than the standard price.

Mr. I. H. Wright : I had looked forward with great interest to the paper which Mr. Lightbody promised to give us. To-night, he has met all my expectations, and from the general tone of the discussion I take it that the audience are very distinctly interested. I remember how things used to be done quite a number of years ago, and it has been interesting to me to compare things to-day with those early days before the war, and see the way in which progress is being made. I come from a district in which a simple kind of work was carried on, and have been in a district where repetition manufacture is an everyday thing, and the most striking thing, I think, is this method of getting to know what you are doing immediately, and not, as Mr. Lightbody has said, a month or so later, when probably no one ever hears about it. I beg to second the vote of thanks.

Mr. Lightbody : Thank you for your vote of thanks. Perhaps at some later date I may be able to give you a more thought-out address on the subject of Costing. I was, twenty-eight years ago, the assistant in this country to the man who invented scientific costing. He went out to America because he said he could not get along in this country quickly enough and made for a number of years a very large income. He began as a skilled engineer,

but was a born cost accountant, and he taught me many things that I still look upon to-day as the fundamentals of costs. Costs, as I said, are just a tool. As historical records they are little use to any one. If your costs cannot be made use of, then the best thing to do is to save the money on the costs and do a little guesswork. In recent years, costs have been looked on, I think, in their proper light and not only management, but the subsidiary form of management, is beginning to take a very keen interest. I think that is all to the good, and I am sure that many of the great savings on costs would never have been made if the costs were not known. I am not too proud to learn; if I go to Germany Holland, France, Italy, America, Canada, or anywhere else I always try to give a little, and, like a Yorkshireman, to get a lot. If you cannot better a man's performance, then the best thing you can do is to copy. Many ideas I see in America are better than ours. I am going to copy them. Many things I know are better than anything I see in America. Many of the things they do in America are what one might term spectacular. Many of them have real worth, and it is certainly a very wonderful thing to me, when I stand in a great concern employing twenty or thirty thousand people, to note the number of different types of men, different in their speech, different in every other way. I was in a workshop looking at a battery of special machines where there were twelve workmen and seven different nationalities, not one of whom spoke either English or American. The management personnel of that company was enormous. I should say that out of every hundred men in that works there were about thirty-five bosses, but the fact remains, that these thirty-five men were all doing real hard, useful work, and instead of standardising a performance and saying that this bolt, nut or connecting rod costs so many hours, they take the last performance and they set about bettering it, and by the time the new year's programme comes round, believe me, there are very few things in that works that are not going to be made a bit cheaper. Money is invested in that way because they have a definite regard for producing quickly and accurately and they do not make any secret of the costs. Their costs are chalked up on boards on the works. You can find out for yourselves what everything has cost—labour, material, overhead and selling charges—and the man from the adjoining works, who is a bitter competitor, comes in and looks at the same figures and goes away to beat them, and if they are going to beat one another, we have got to keep wide awake if we are going to beat them.